WEAPONS
AND MUNITIONS
OF WAR

PART V

FIELD EQUIPMENT OF SIGNAL TROOPS

BY

MAJOR GEORGE O. SQUIER,
SIGNAL CORPS, U. S. A.

DEPARTMENT OF MILITARY ART
INFANTRY & CAVALRY SCHOOL
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DEPARTMENT OF MILITARY ART

INFANTRY AND CAVALRY SCHOOL

FIELD EQUIPMENT OF SIGNAL TROOPS*

By Major Geo. O. Squier, Signal Corps, U. S. Army.

The technical equipment of Signal troops for service in campaign has been rapidly expanded and developed in the past few years, so that at the present moment no well informed military commander fails to demand the best which this service affords for his field operations in campaign.

The fact that widely separated bodies of troops can now be maneuvered and fought under the guidance of one central intelligence, permitting an extent of terrain hitherto impossible, is due primarily to the development and efficiency of military electrical lines of information and control.

The element of *time* has always been a paramount factor in war, and the electrical messenger has no competitor when the distances involved are those now met with in modern combat.

It will be the object herein to give in brief outline, without detailed description, the principal technical apparatus and appliances now furnished Signal troops for field service.

ELECTRICAL EQUIPMENT FOR MILITARY LINES OF INFORMATION.

Electrical methods of intercommunication for military field lines of information have been developed

*Compiled for use in connection with practical demonstrations with the apparatus described.

to such perfection that they have become of first importance in war.

For strategic lines of information, in the event of war in any civilized country, the existing systems of commercial telegraphy will, of course, be adapted and utilized. It is not necessary to more than mention here the types of instruments used for this purpose, as they are familiar, in a general way, to every one. The American system of commercial telegraphy employs the Morse code of Signals, which is read by sound. This code is made up of dots and dashes in different combinations to represent the individual letters and conventional signs needed for the transmission of intelligence. The European system employs a slightly different code, known as the "Continental Code," whereby the signals are usually received upon a strip of paper recorded in ink giving a permanent record. This system of commercial telegraphy employs conducting wires elevated on poles, and is represented by the enormous telegraph plant which now exists in this country and throughout the civilized world.

For semi-permanent lines erected by Signal troops in the field, the conducting wires are strung on light lance poles and operated by simple and portable instruments known as the closed-circuit relay and sounder, and the pocket relay, all constructed on similar principles.

The closed-circuit relay can be used over well insulated lines for distances up to about 500 miles, and over hastily constructed field lines about 150 miles. With these instruments it is essential to have good insulation, good joints in the wire, and good ground connections, since the earth is used as a part of the telegraph circuit.

By the use of "telegraph repeaters" messages may be transmitted over land lines without limit as to distance.

THE "BUZZER."

This instrument, in its present developed form, is believed to be superior to that used by any other army in the world. The Japanese "buzzer" is almost an exact copy of the Signal Corps buzzer, but lacks some of its good points.

As stated above, the standard Morse relay and sounder require comparatively carefully constructed telegraph lines giving good electrical insulation from the earth. Tactical field lines, built and operated under service conditions, cannot insure this construction, and an instrument whose operation depends on other principles became a necessity long ago. The first prominent mention of such an instrument in military telegraphy was by Major Cardew, R. E., in 1881. Its utility, through a poorly insulated line, where the ordinary Morse instruments were impracticable, was mentioned in the account of the expedition of the English up the Nile in the attempt to relieve Gordon at Khartoum in 1884.

The Signal Corps of the Army has experimented with this instrument for a number of years and developed in succession types of buzzers until the present latest model of field buzzer has been evolved, and is now issued to all Signal troops for service in campaign. The buzzer substitutes for the ordinary telegraph relay, used in commercial telegraphy, the head telephone as a receiving instrument; and as a transmitter sends out upon the line a succession of pulsatory electrical currents of high electromotive force in place of the single impulses of low potential used in ordinary commercial telegraphy. Without entering into a detailed engineering description of this instrument, it may be said that the theory of the buzzer is based upon the fundamental principles of the efficient transmission of electrical energy over poorly insulated lines, namely, transmitting the energy at a

comparatively high voltage and low current instead of at low voltage and larger current; the energy transmitted being always proportional to the product of these two factors.

The American army in the Philippines and in China has made extensive and continuous use of the buzzer as a means of maintaining communication between an army in the field and its base, and as an habitual method of telegraphy over hastily constructed lines where the insulation was too imperfect for Morse working. In the recent Russo-Japanese war the field buzzer was extensively used.

Without describing the actual wiring of the standard field buzzer, the following explanation of the action of the instrument will give the principles involved:

Each of you, no doubt, has noticed the phenomenon of the electric spark, which can be produced in a variety of ways.

If we have a source of electromotive force, such as a few dry cells of ordinary battery, joined up in series and connected outside by a conducting wire, it is noticed that when the wire outside is connected, thus completing the circuit, no spark is produced; whereas when the circuit is broken, such as by removing the wire from one of the terminals of the battery or in any other manner, as with a key, a minute spark may be observed. Modern theory shows that at making the circuit, which permits a current to flow from the battery, the energy of the current is used up in producing strains in the medium surrounding the wire, and in heating the wire itself, so that at "making" the circuit no spark is produced. On "breaking" the circuit, however, the energy which has been stored in the surrounding medium, which is the ether pervading all space, is given back and appears in the form of light and heat at the ter-

minals of the break in the circuit, and is known as the electric spark. If, instead of connecting the terminals of the battery directly by a conducting wire, we insert in the circuit a coil of wire surrounding a piece of soft iron and then repeat the experiment, it will be noticed, as before, that at the instant of "making" the circuit with the key or otherwise, no spark is observed; whereas in this case at the instant of "breaking" the circuit a much greater spark is seen. Furthermore, the length and size of this spark will depend upon the suddeness with which the break occurs. We have here introduced what is known as the phenomenon of self-induction, and measurements would show that the spark in the second case had a much higher voltage or tension than in the former case, where it is limited to the voltage of the battery used. If we should also connect an ordinary telephone receiver in the circuit we would hear the clicks in the receiver whenever the circuit was broken, but the sound can be made much louder in the second case when the coil is used. In other words, the coil is a simple device for transforming the energy of the low voltage battery into a form having higher potential or greater voltage, which latter quality serves to drive the current produced over greater distances when used on poorly insulated lines.

Instead of "making" and "breaking" the circuit by hand as explained above, it may be done with more regularity and suddeness by using an automatic interrupter, which consists essentially of a straight, stiff spring momentarily attracted by the iron core of the coil every time the circuit is closed by the sending key, and immediately restored by the action of the elasticity of the spring itself. Such interrupters may be easily adjusted to give very regular vibrations and produce a definite note to the ear. In this case when

the telegraph key is closed, a succession of regular interruptions to the current occur until the key is released, and by holding the key down for shorter or longer periods, the elements of the Morse code may be produced.

In addition to providing this means for field telegraphy, the latest pattern buzzer is also invariably furnished with a specially constructed telephone transmitter suitable for field work, and means provided for using the instrument as a telephone set, independent of its use as a telegraph set. The same telephone receiver is used to hear the Morse signals in the one case and speech in the other.

This is accomplished in the field buzzer by means of a simple switch placed in the side of the telephone transmitter, so that when using the instrument as a telephone set this switch button must be depressed. The operation of the switch is to introduce a part of the battery into the coil circuit instead of the key and interrupter.

It may often be desired to utilize existing telegraph lines as a part or the whole of the circuit for buzzer working, at the same time not interfering with the use of the wire for Morse working.

This is effected by using condensers between the line and the buzzer. Each condenser consists of many sheets of tin foil separated from each other by sheets of paraffined paper, all the alternate sheets of tin foil being connected together, thus making two sets of tin-foil leaves; the two sets being separated by the paraffined paper yet being very close together. No current will flow through the condenser if the battery be steadily applied, and, therefore, if one set of leaves is connected with the telegraph line and the other set with the ground, no appreciable effect will be produced by the comparatively slow pulsations of the ordinary Morse sending.

If buzzers are bridged on to a part or the whole of such a telegraph line where ordinary Morse working is being used, the rapid pulsations of current produced by the buzzer readily pass through the condensers which are contained inside the buzzer case, and are transmitted to the distant buzzer without affecting the Morse relays or sounders in regular use on the line, since the changes of current are so rapid that the armatures of the telegraph relays have not time to respond. These rapid pulsations are, however, readily taken up by the more delicate telephone receiver used in the buzzer as a receiving instrument.

The field buzzer is substantially mounted in compact form in a wood and sole-leather case, with an adjustable strap to sling it from the shoulder. It weighs 11 pounds complete and can be carried by mounted men for reasonable distances, although, as will be explained later, it is carried on the march with other equipment either in the chest of the field-wire wagon or in the squad boxes provided for pack transportation.

THE CAVALRY BUZZER

The cavalry buzzer adopted for the Signal service is an extremely neat and compact form of the buzzer especially designed for use with cavalry, where the equipment must be carried habitually by mounted men. The principles of this instrument are identical with those of the field buzzer just described, but there are several changes which make for compactness and portability. Dry cells are used but they are very small, and the telephone transmitter and receiver are both mounted together on an adjustable frame so that they may be carried in the smallest space possible and both used with one hand.

The switch employed, when the instrument is used as a telephone set, is contained in the handle of the

frame. The telegraph key is merely a button in the top of the case and may be used without removing the leather case. This instrument is especially adapted for rapid field lines such as used in service with the cavalry screen or with outposts, etc., where light field buzzer wire laid directly on the ground may be used. The instrument weighs five pounds complete, and is carried in two small leather cases both swung from the same adjustable shoulder strap.

It is believed that two of the present cavalry buzzers (one set) should be issued to every company of infantry and every troop of cavalry in our service, for use in their own interior intercommunication, in addition to all other methods of information furnished them from the outside by Signal troops.

For a company of infantry on outpost or similar duty, such an equipment would be simply invaluable, and as the present regulations require that two men in each organization shall be instructed in signaling, these men would naturally be the ones to carry, install, and operate this equipment.

FIELD TELEPHONE.

The Signal Corps has experimented for a number of years looking to the development of a portable field telephone without any telegraph arrangement, for use in the field, in semi-permanent camps, on the march, etc., where a telephone service only is desired. The great advantage of the telephone is that it requires no trained operators to use it, and that commanding generals and others may have the advantage of direct and confidential communication without the intervention of other parties, and also with the least possible delay; whereas the telegraph with trained operators possesses great advantage for the transmission of orders and instructions on the battle field, since it is much more accurate and reliable and gives

a permanent record of both the transmitted and received message. The telephone always has at times its peculiar advantages, and is therefore invariably supplied in the field buzzer outfit.

The field telephone, being solely a telephone set, is superior for telephone practice alone to that provided in the field buzzer equipment.

In the field telephone the essential parts are the transmitter, the receiver, and the calling apparatus. These parts do not differ in principle from those used in commerical telephone practice, except that they are made in more substantial and compact form.

The transmitter and receiver are mounted on the same hand support so that one hand only is required for conversation; the wiring is very strong and durable, and all parts can be readily examined in case of trouble. The case is neatly made of wood with metal corners and as far as possible is weatherproof. The whole equipment weighs about twenty-one pounds, and has a strap sling for carrying purposes. The theory of the telephone transmitter and receiver and the practice as used in the Signal Corps is clearly given in the Signal Corps Manuals issued to officers and non-commissioned officers of the Signal Corps.

A field cordless telephone switchboard has been devised, and is used in the equipment of field "central" stations where several field lines converge, such as at army, division, or brigade headquarters. This board is very compact and may be mounted either directly upon the ground or upon a tripod furnished for the purpose.

FIELD WIRELESS TELEGRAPHY.

There has been developed recently a satisfactory equipment for field wireless telegraphy, and experiments are now being made with the Army of Cuban Pacification to determine the possibilities and limita-

tions of this method of signaling for the field operations of an army. This subject is also being studied practically and theoretically in the U. S. Signal School, and a complete equipment for two field stations has been recently received here.

This equipment, includes a sixty-foot mast, comprising jointed sections, which is held in an upright position by guy ropes. With a trained detachment, the mast can be erected and the whole station installed in 15 to 20 minutes. The apparatus, including transmitting coil, condensers, keys, electrolytic receiver, head telephone, etc., is assembled in two pack-chests, so that the entire outfit including the mast weighs but 320 pounds, and can be easily transported on two pack mules. The electric current is supplied by portable storage batteries, which are conveniently mounted for transportation, and they are recharged by a small gasoline-driven dynamo at the base of operations. For convenience in operating in the field, a tripod is furnished for mounting one of the chests. Several of these field outfits have already been furnished the Army of Cuban Pacification, and field messages are regularly transmitted and received by them over distances of twenty-five to thirty miles, while messages have been received at Camp Columbia, Cuba, from the wireless station at Key West, 125 miles distant.

In addition, the Chief Signal Officer of the Army is at present constructing fifteen sets of field wireless equipments for tests during summer encampments. These sets aim to still further reduce the weight of this complete equipment, which will be contained in one small pack-chest made up like a trunk, having a length of about thirty-two inches, a width of about twenty inches, and a depth of about twelve inches, the weight being but about 140 pounds, not including the small portable battery.

This small chest with two storage batteries and the jointed mast, will probably be transported on one mule.

There is no longer doubt that wireless telegraphy will play an important part in the military field operations of the future. The maintenance of a wire between stations always presents obstacles to reliability and efficiency, especially when the wire is in a military terrain. France and Germany has each developed portable wireless field outfits for military purposes. These outfits comprise, in general, some type of portable engine and dynamo, transformers, portable balloon or mast, etc., requiring several wagons for transportation, and a considerable trained personnel for successful operation. The principal obstacle to field wireless work has been the necessity for transporting some form of mast, captive balloon or kite, to sustain the vertical aerial. Last year, at this station efforts were made to develop a more mobile outfit than had been heretofore attempted, and one suited to pack transportation. The object was to attain distances of twenty-five to fifty miles, for use with a cavalry screen, outlying posts, and so forth. To avoid the necesssity of transporting a mast or balloon for sustaining the antennae, special forms of kites were experimented with here with good success. These kites have been regularly adopted as a part of the Signal Corps field equipment. They are made in standard sizes, and may be flown either singly or in tandem. They are made of fine Japanese silk mounted on light bamboo frames, and are collapsible so that they may be folded up in a very small compass. These kites are held captive by the buzzer wire used in field operations, which also serves as the transmitting and receiving antennae. This wire is paid out from a specially constructed reel, highly insulated from the ground by porcelain legs. The ground con-

nection for both transmitting and receiving, is effected by spreading out upon the surface of short, thick grass a copper wire netting of comparatively fine mesh. It is of advantage that the earth connection should be surrounded for a considerable distance on all sides with moist earth well covered with short grass.

With this simple outfit which could be installed in a few minutes, whole messages were received at this station from St. Louis, Chicago, and from ships in the Gulf of Mexico.

Since the distances to which messages may be transmitted depend primarily upon the power of the transmitting station, the equipment described was not adapted for sending to such great distances as mentioned above, but messages were easily exchanged between this station and the wireless station at Kansas City, Missouri, a distance of over 30 miles.

The equipment necessary for receiving messages only can be made extremely simple, so much so that it need weigh but a few ounces and may be carried by a single soldier without inconvenience. In such cases no other form of receiving antennae need be used than a vigorous growing tree, preferably well covered with leaves. It is only necessary to drive an ordinary nail into the trunk of a tree at some distance from the ground, and connect this nail, through a small pocket electrolytic receiver, to a small iron pin driven into moist earth near the tree; when passing messages may be clearly read by means of a head telephone suitably connected to the receiver.

COMBAT TRANSPORTATION.

The combat transportation for field lines of information will be merely enumerated here, as ample opportunity is afforded for observing its technical use

in field exercises and maueuvers. At present it comprises the following:

Automatic Field-wire wagons,
Automatic reel carts,
Lance trucks,
Instrument wagons,
Construction wagons,
Balloon wagons,
Standard squad boxes, } for pack transportation.
Standard pack chests, }

TYPES OF WIRE USED FOR FIELD SERVICE.

No. 14 g. i. wire, weight 96 lbs. per mile;

19-strand insulated field wire, weight 120 lbs. per mile.

11-strand insulated field wire.

Buzzer wire, partially insulated, weight 5 lbs. per ½-mile coil.

The light buzzer wire is habitually transported in half-mile coils, and is paid out or recovered from a hand or breast reel carried by a mounted man. In laying and recovering such lines mounted signalmen are employed who carry short wooden pikes, with a special hook at the end, so that the wire can be handled almost entirely without dismounting.

VISUAL SIGNALING.

Electrical means of intercommunication have very largely superseded visual methods for obvious reasons, yet there are occasions when no other means of transmitting information are practicable or available and where its use will be of vital importance.

In the Japanese army visual signaling is practically non-existent. That this is so is probably due to the fact that the Japanese language does not lend itself to transmission by flag or heliograph, having no regular alphabet like our own. There has been devised, however, a code on the basis of the continental

Morse code which admits of telegrams being transmitted. This code, for the purpose of visual signaling, is unwieldy and cumbersome.

Undoubtedly another reason why the Japanese do not use visual signaling is on account of the difficulty of keeping messages *secret* when so sent.

The correct and economical use of visual signaling depends upon the exercise of sound judgment, and the efficient signal officer will always use the particular means available for the most expeditious delivery of information, with the transmission of which he is charged.

For instance, a message of one hundred words to be delivered at a distance of half a mile could probably best be sent by a mounted orderly, if circumstances permitted, whereas if the same message were to be delivered five miles, electrical or visual methods of signaling would be vastly superior. It is primarily a matter of length of message and distance of transmission.

In all methods of visual signaling, where the words are spelled out letter by letter, the Army and Navy code is authorized and required. This code is known as the Myer code, and consists of three distinct elements, representing the numbers 1, 2 and 3. These figures are arranged in combinations to represent each letter of the alphabet, the numerals, and certain conventional signals. Each element is represented by a motion of the flag, or flash of the lamp or heliograph.

FIELD VISUAL SIGNALING APPARATUS.

The field visual signaling apparatus of Signal troops consists of three principal instruments, the flag, heliograph and acetylene night lamp. Smoke rockets, sequence rockets and bombs are also used. The flags are made of light durable cloth, and are is-

sued in three sizes, 2 by 2 feet, 4 by 4 feet and 6 by 6 feet; the last is seldom used at present. These flags are attached to staffs having three joints, each joint of which is four feet long. In general, the greater the distance to be signaled over, the longer the staff should be so as to give a greater arc when swinging the flag. The flags are of three colors, white with a red center, red with a white center and black with a white center. The colors to be used depend on the background. The greatest contrast between flag and background is desired. A four-foot flag on a twelve-foot staff can be read clearly up to seven miles on a clear day. Its rate of operation in the hands of experts will range between three and four words per minute. Fog, darkness, rain and other unfavorable conditions of weather reduce its working distance and rate of operation.

THE HELIOGRAPH.

The advantages of the heliograph for visual signaling are its portability, great range, and the comparative rapidity with which it may be operated. Its flashes can be seen only by those approximately on a right line connecting the stations between which communication is had, and it can be operated over terrain occupied by the enemy.

Under favorable atmospheric conditions and where signaling is to be continued for some period, the heliograph has replaced the flag. With it messages can be more readily sent, while its range is many times greater. Dust and smoke, which would totally obscure even the largest flag, are readily penetrated by its flash. Through smoke and haze so dense that the sending station could not be seen, even with a signal telescope of 30-power, its flashes have been read by the unaided eye at distances of fifteen miles.

The heliograph is a very good visual instrument if proper conditions for its use prevail. Its rate of operation is from five to twelve words per minute, and its range, under suitable atmospheric conditions, is limited only by the curvature of the earth. Heliograph messages have been sent over distances of 180 miles. To use a heliograph successfully both stations must have use of the rays of the sun, as clouds, fog or rain prohibit its operation.

In general terms, the principle of the heliograph is that of the reflection of a parallel beam of sunlight by a plane mirror or mirrors—the angle of incidence being equal to the angle of reflection.

In case the sun is in front of the plane passing through the sending station and normal to the line joining the two signal stations, but one mirror is required, and but one reflection of the sun's rays used. The mirror is mounted on a suitable tripod and is placed at such an angle that the sun's rays will be reflected squarely upon the distant station. A separate tripod carries a shutter operated by a hand key, which shutter can obscure the reflected flash for a longer or a shorter period and thus the elements of the Myer or Morse codes are formed and transmitted to the distant station.

In case the sun is in rear of a plane passing through the sending station and normal to a line joining the two signal stations, two mirrors are required and two reflections of the sun's rays are accomplished in order to flash the beam to the distant station.

By having a small unsilvered spot in the center of one mirror and a corresponding paper disk in the center of the other, the two mirrors are adjusted at the proper angles to cause the doubly reflected beam of sunlight to be flashed directly upon the distant station. The principle of the adjustment is similar to that employed in sighting the rifle, where the rear

sight, front sight and the target are brought into the line of sight. Adjustment of the sun mirror, which contains the unsilvered spot, to correct for the apparent motion of the sun, is effected by means of slow-motion screws attached thereto.

When a heliograph is used at a distance of five miles or less in bright sunshine, the sending mirror may be covered with a piece of cardboard or blotting paper having a square of about two inches on a side cut out of the center. While the reflected beam will be of the same diameter, it will not be so bright, and consequently less tiresome on the eyes of the reader, while being sufficiently distinct to be easily read. When this is not done, dark eye-glasses should be provided and worn.

ACETYLENE LANTERNS.

Acetylene is a pure hydrocarbon gas, which can be produced in various ways. The methods in use by the Signal Corps are by dropping calcium carbide into water or by dropping water upon calcium carbide. In the manufacture of calcium carbide for commercial purposes the best quality of coke and quicklime are used. The two substances are powdered, thoroughly mixed in proper proportion, and then placed in an electrical furnace. Under the action of the intense heat (5,500 °F) these two refractory substances unite, forming carbide of calcium. Calcium carbide is of a greyish-white color, crystal in appearance, and is non-explosive and non-combustible, being, except for its affinity for water, an absolutely inert substance. When water is brought in contact with calcium carbide the generation of acetylene is rapid; a pound of commerical carbide will produce approximately five cubic feet of gas. Acetylene is explosive when mixed with air in proper proportions, confined and ignited; and the same precautions should therefore be taken

in its use as would be employed in the handling of coal gas, gasoline vapor, etc.

In order to get a flat flame the gas is brought through two round holes at an angle which causes the two flames to impinge upon each other, thus forming a flat flame.

There are in use by the Signal Corps two types of acetylene signal lanterns—the field signal lantern and the station signal lantern. As is indicated by their names, they are designed for special uses; the former, being small, light in weight, very easily transported, and simple to set up and take down, is especially adapted for field work where stations are but temporary.

The station signal lantern is a larger instrument o" greater candle-power than the field lantern, and is especially adapted for long distance work, and where stations will be of a more permanent character.

The field acetylene lamp is capable of being read with the naked eye up to fifteen miles. Fog and rain are the principal impediments to its use; a bright moon also interferes. As conditions are more uniform at night than in the day time, this lamp is probably the most reliable night visual apparatus. It can be worked by experts from five to ten words per minute.

THE FIELD LANTERN.

The equipment for the field lantern consists of a special aplanatic lens mirror five inches in diameter and of about three inches focus, suitably mounted in a brass frame all parts of which are riveted. The burner is of the double tip form consuming about three quarters of a cubic foot of gas per hour. The lantern is fitted with a hood to provide proper ventilation, and at the same time prevent the flickering of the light by the wind. The cover glass is made in three sections and is not affected by the expansion

and contraction of the metal due to changes in temperature. In the base of the lantern is a key and the adjustment for regulating the height of the flame. The key is so arranged that when not depressed but little gas is admitted through the by-pass to the burner, and the flame is low. By depressing the key as much gas as can be entirely consumed is admitted to the burner, which gives a bright flash. At the back of the lantern there is an adjustable handle, so that the equipment can be used as a hand lantern if desired. This form of lantern can be used with the regular form of heliograph tripod. The cartridge generator constructed on the water. feed principle, can be attached either to the back of the lantern or suspended from the tripod. Suitable charges of calcium carbide are contained in air-tight cans which are readily inserted in a frame in the generator.

THE STATION LANTERN.

The station signal lantern is a larger apparatus adapted to long distance work of a more permanent character. The frame of the lantern is made entirely of brass in cylindrical form. Four acetylene burners are mounted in this cylinder, in one end of which is a plano-convex lens, five inches in diameter and six-inch focus. The burners are arranged in line on the axis of the lantern with the center of the cluster adjusted in the focus of the lens. In the back of the lamp opposite the lens is a concave spherical mirror with its center of curvature in the center of the cluster of flames. This arrangement gives great concentration for projecting a parallel beam of light. In the operation of the station lamp the carbide is held in a conical-shaped hopper, mounted over water contained in a tank holding about a gallon. In both types of signal lantern, the signals are made by

turning gas on and off intermittently, by means of the above mentioned key or valve which is operated by a button similar to that used in a standard Morse telegraph key. The action of the key in responding to the touch of the operator is instantaneous. The by-pass valve attached to the key supplies a quantity of gas to the burners to keep them from going out when the pressure is removed from the button.

As a single example of the value of visual methods of signaling under stress of circumstances, it may be mentioned that for many months during 1900 and 1901 regular communication by heliograph and flash-lantern was maintained between Argao on the Island of Cebu and Loon on the Island of Bohol, Philippine Islands. These stations were regularly established in a permanent manner, and transacted all of the military and administrative business of the Government pertaining to the Island of Bohol; there being no other means available at the time for establishing communication.

ROCKETS AND BOMBS.

Signals made by the explosion of bombs or rockets in mid-air are, within the limits of visibility, not likely to be unseen or misunderstood, and in consequence this method of signaling is often of much value for preconcerted or code messages when electric inter-communication is not available. Outposts, when not provided with more efficient means of inter-communication, may use rockets for signaling the approach of the enemy or the happening of unexpected events, the necessity for promptly knowing which is important. Signal bombs are pasteboard shells, charged with stars which burn brilliantly when ignited. Generally they are fired from mortars—hollow iron cylinders closed at one end, two or

three feet in length, and of sufficient diameter to readily admit the bomb.

Three kinds of rockets, the sequence, light and sound, and smoke rocket, and two kind of bombs are used in the Signal Corps. The sequence rocket is so arranged that it can be loaded with different colors at any time. Four lights in sequence may be used. By using the Myer code any letter or number may be signaled with one rocket, thus messages may be exchanged by using any code desired. The lights used are red and white. The red signifies the 1 in the Myer code, the white 2. A good sequence rocket attains an altitude of 1000 feet. The light and sound rocket is used for the purpose of attracting attention or indicating a prearranged signal. It can not be loaded at will like a sequence rocket. It attains about the same altitude as a sequence rocket and discharges with a loud report displaying a white light. The smoke rocket is used in the day time and is arranged so that upon exploding a deep-yellow smoke is displayed. It attains about the same altitude as the others. Rockets are used for signaling across impassable places to indicate movements that apply to a whole organization, and may be used for a party that is in thick timber or a declivity where no elevation can be attained for direct signaling. Rockets can be read at a distance of about six miles, weather permitting.

Rockets and bombs while they convey information to our own forces, may also disclose our position to the enemy, and, therefore, their use is always preeminently a matter of good judgment.

CODES AND CIPHERS.

Message codes are devised for use in field service in order that preconcerted phrases may be expeditiously transmitted. Between stations, where it would

be necessary to send messages of great importance in the shortest possible time, codes are arranged in sentences, and opposite each sentence is placed one, two, or more letters of the alphabet to designate it. Such conventional signals serve a most useful purpose in time of war, and signal officers should endeavor to anticipate urgent messages and replies thereto, and prearrange signals to represent them. Important messages which may fall into the hands of the enemy, or signal messages which might be read by him, should invariably be enciphered. Much care is necessary both in enciphering and deciphering messages. A simple device for use in the field consists of the cipher disk. This, in its simplest form, is composed of two circular disks of card board or other material joined concentrically, the upper disk revolving upon the lower. The diameter of the upper disk is made less than that of the lower disk. The alphabet, reading clockwise, and such other signals, numerals, or combinations of letters, as may be desired, are printed around the circumference of the lower disk. On the upper disk are also printed the alphabet, and the other signals, numerals, or combinations of letters; except that they are there printed counter-clockwise.

If it is desired to encipher a message in the simplest manner with this disk, a "key" letter is agreed upon beforehand, and the message enciphered as follows: Place the "key" letter of either one of the disks opposite "A" of the other disk. With the disks in this fixed relation, read in succession the letters on one disk opposite the letters occuring in the message to be sent in regular succession as found on the other disk. This will give evidently a succession of letters having no meaning until deciphered by the reverse process at the receiving station. To further complicate it, it is usual to arbitrarily break up the cipher letters thus obtained into uniform groups of four or

five letters each, regardless of the number of letters in the separate words of the message. Messages enciphered in this simple manner are very easy to decipher, but the process can be made more difficult by adopting a key word or sentence instead of a key letter, when the setting of the disk is changed as each letter is enciphered. Great ingenuity has been displayed in enciphering military messages in the past, and although an expert can ultimately work out the "key" to almost any system devised, yet the time required to accomplish this can easily be made so great as to practically destroy the value of the information when obtained.

The route cipher consists in writing the words of a message in columns of three, four, or more; then sending the first word in each column consecutively in the message, next the second row of words and so on, or by interchanging the columns or sending blind words, etc.

An almost infinite variety of methods for concealing military information will suggest themselves to a resourceful officer, and it is not necessary to further pursue this subject here, except to remark that when very important messages are in danger of being captured when in your possession, an efficient method is to carry the message in the barrel of a loaded revolver or rifle, where it may be easily disposed of by firing the piece in case of surprise.

FIELD-GLASSES AND TELESCOPES.

There is no more generally useful part of the equipment of an officer than an efficient field-glass.

The human eye is the standard upon which are based the qualities of field-glasses and telescopes. The properties of these instruments are therefore expressed generally in terms of power, field, light and definition. There are but two general types of field

glasses, the Galilean and the Prismatic, although there are many makes of each type. The Chief Signal Officer of the Army has for a number of years conducted experiments with a view to determining the best types of field-glasses and telescopes for issue to the service. The general results of these tests clearly show that no one type of either gives satisfaction under all circumstances. Varying conditions of temperature, humidity, and clearness of atmosphere require different types. The most important property of a glass is its definition, that is, the sharpness of the image seen through it, yet the properties of power, light, and field are but little less important.

No single field-glass can furnish a maximum result as to these four properties, and in consequence all glasses must be compromises. In addition, whether a glass is held by a mounted man with a free hand, by one on foot, or in a holder, makes a difference as to the power which can be advantageously used. The best that can be done is to select certain standard glasses, leaving the individual free to utilize the special advantages of the glass most nearly suited to his eyes, position, locality, and special needs.

The Signal Corps Day and Night field-glass, Model 1905, is the result of the efforts of the Signal Corps to provide a field glass that will meet the greatest variety of conditions, and insure efficient service to the greatest number of military observers. It is really two glasses in one, namely, a day glass of high power, and a night glass of low power. This glass is a very good one for moderate ranges, but it does not replace under special conditions for long ranges, either the Porro-prism glass or the telescope. This double glass is secured by interposing automatically, just in front of the eye-pieces, small plus lenses which operate to change the power. All that is necessary to change the glass from a day glass to a

night glass is to turn it over, since the operation of interposing the lenses is accomplished automatically by gravity. A different adjustment of the tubes is, however, required to get the proper focus for each. As a day glass, the power is about five and six-tenths diameters, and the field about five and four-tenths degrees, and when used as a night glass, the power is reduced to about three and eight-tenths diameters, and the field increased to eight and three-tenths degrees. The glass complete with case, cord and straps weighs twenty-one and one-half ounces.

For military purposes, a field telescope must have suitable form, small volume, and little weight, and, in addition, must be capable of being used without support if necessary, mounted or dismounted, and also the image must appear erect. For general signal purposes, a telescope of a power of about thirty, with the best definition and light obtainable under these requirements, has been found most satisfactory. The Signal Office at present issues field telescopes of 18 and of 24-power, with tripod complete packed in a leather carrying case.

FIELD SEARCHLIGHTS.

Since the Russo-Japanese war where night operations of various kinds were used more frequently than had been previously supposed advisable, the necessity for providing a compact and mobile searchlight equipment for field service has been accentuated.

It will be sufficent here to describe in general terms the portable searchlight equipment, at present used in the Signal School. This equipment is provided with an eighteen-inch projector, and a steam engine and direct current generator, the whole mounted on two wagons. The reflector proper, with the automatic feed mechanism and a steel shield to protect the

operator, is on one light wagon drawn by two mules. A strong, well insulated electric cable permits the projector's being operated in advanced and elevated positions while the other wagon carrying the engine and dynamo, which is heavier and requires four mules, may be safely screened at some distance to the rear of the light itself. This equipment has been tested at this station with a view to determining to what extent accurate shooting with the service rifle and with machine guns may be done at night.

In general, it may be said that at the shorter ranges, under proper conditions, almost as good scores can be made at night on the regular service target as may be made in the day time.

These preliminary results indicate that in addition to the use of field searchlights in detecting and following the movements of an enemy at night, searching for the wounded, screening intrenching operations, etc., it may be also used to greatly increase fire action under conditions which otherwise would amount to practically a waste of ammunition.

The use of searchlights in conjunction with Field Artillery was also investigated to a limited extent during the past summer at Fort Riley, Kansas, where the equipment above described was sent for the purpose.

We may leave this subject, thus briefly mentioned, by saying that field searchlights are a necessity to a properly equipped army, and more so than ever since the revival and extended use of the night attack in the Russo-Japanese war.

BALLOONS AND AIR MACHINES.

At the present moment, the subject of military aeronautics is receiving very careful consideration, and it is hoped that within the next year a systematic and practical course of instruction in this important

subject may be furnished to the service schools here. Up to the present time the Signal Corps has had only very limited experience in balloon work, and this entirely with captive balloons of small dimensions, such as were used at Santiago in the Spanish-American War. However, plans have been developed and money appropriated for the construction of a hydrogen gas generating plant and compressor for the purpose of producing hydrogen gas and storing it under pressure in steel tubes, suitable for shipment and transportation with an army in the field. This method is now considered absolutely necessary, since the apparatus previously used in foreign armies, by which the gas was generated in the field, is so cumbersome and immobile as to make it prohibitive. The best gas to use in balloons is pure hydrogen, although ordinary illuminating gas, which has about twice the specific gravity of hydrogen, may be employed.

It is a matter of special pride to the army that at the balloon contest in France in September last, at which sixteen contestants started, the record was made by 1st Lieutenant Frank P. Lahm, Sixth U. S. Cavalry. In his balloon, the "United States," he covered the distance of four hundred and ten miles between Paris and Fyling Dales, Yorkshire, England, in twenty-two hours and seventeen minutes.

At present the Chief Signal Officer of the Army has under construction at New York the first of a series of balloons of great size, which are to be used for instruction, service tests, and experiments. This balloon will be about 54 feet in diameter and will have a capacity of about 78,000 cubic feet. It will consist of 2,700 separate pieces of the material used, a combination of percale and linen.

The netting which is being made of specially imported Italian hemp will weigh 286 pounds. Its meshes will be half as large as the meshes of netting here-

tofore used, thus doubling the strength in this respect.

The car will be six feet long, five feet wide, and four and one half-feet high and will be large enough to carry the operating crew and an additional weight of over a thousand pounds. Four men will be sufficient to manipulate it. By means of a ripping strip, twenty-five feet in length, it will be possible to deflate the balloon within about half a minute.

Although balloons, both captive and dirigible, have amply justified their use as an adjunct in war, yet it is to the attainment of a successful flying machine heavier than air, capable of carrying considerable loads, and producing a speed of thirty to fifty miles an hour that the military student at the present moment looks with keen concern. In this connection it should be stated that the first practical flying machine is an established fact and is the creation of the Wright Brothers of Dayton, Ohio. Each of the Wright Brothers has made numerous flights over their testing field near Dayton, some times at an elevation of about eighty feet and at other times passing close to the earth at only about ten feet from the ground. They have been able to circle over the field of operation and even to describe in the air the figure eight, thus demonstrating their perfect control over their apparatus, both in the vertical and horizontal directions. They have succeeded in remaining continuously in the air for thirty-eight minutes, and then descended only on account of the exhaustion of fuel supply. The velocity attained was about thirty-seven miles per hour. The machine has not only sustained its own weight, but has also carried a man, and a gasoline engine weighing 240 pounds, exerting a force of twelve to fifteen-horse power, and in addition an extra load of fifty pounds of pig iron. The apparatus complete with motor weighed not less than 925 pounds,

while the supporting surfaces consisted of two superposed aeroplanes each measuring six by forty feet, so that the machine as a whole had a flying weight of nearly two pounds per square foot.

If nothing else had been accomplished in this direction, the performances of the Wright Brothers in the United States should be sufficent to cause the War Department to undertake the further development, and ascertain the possibilities and limitations of such a weapon in warfare.

The Aero Club of America is doing pioneer work in aeronautics, and it would be of great advantage to the War Department if a similar organization among National Guard members of State Signal organizations was effected to encourage the development of the military side of the subject at summer maneuvers.